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NATIONAL ACADEMY OF SCIENCES
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BIOGRAPHICAL MEMOIRS
PART OF VOLUME VIII

BIOGRAPHICAL MEMOIR

OF

CLEVELAND ABBE

1838-1916

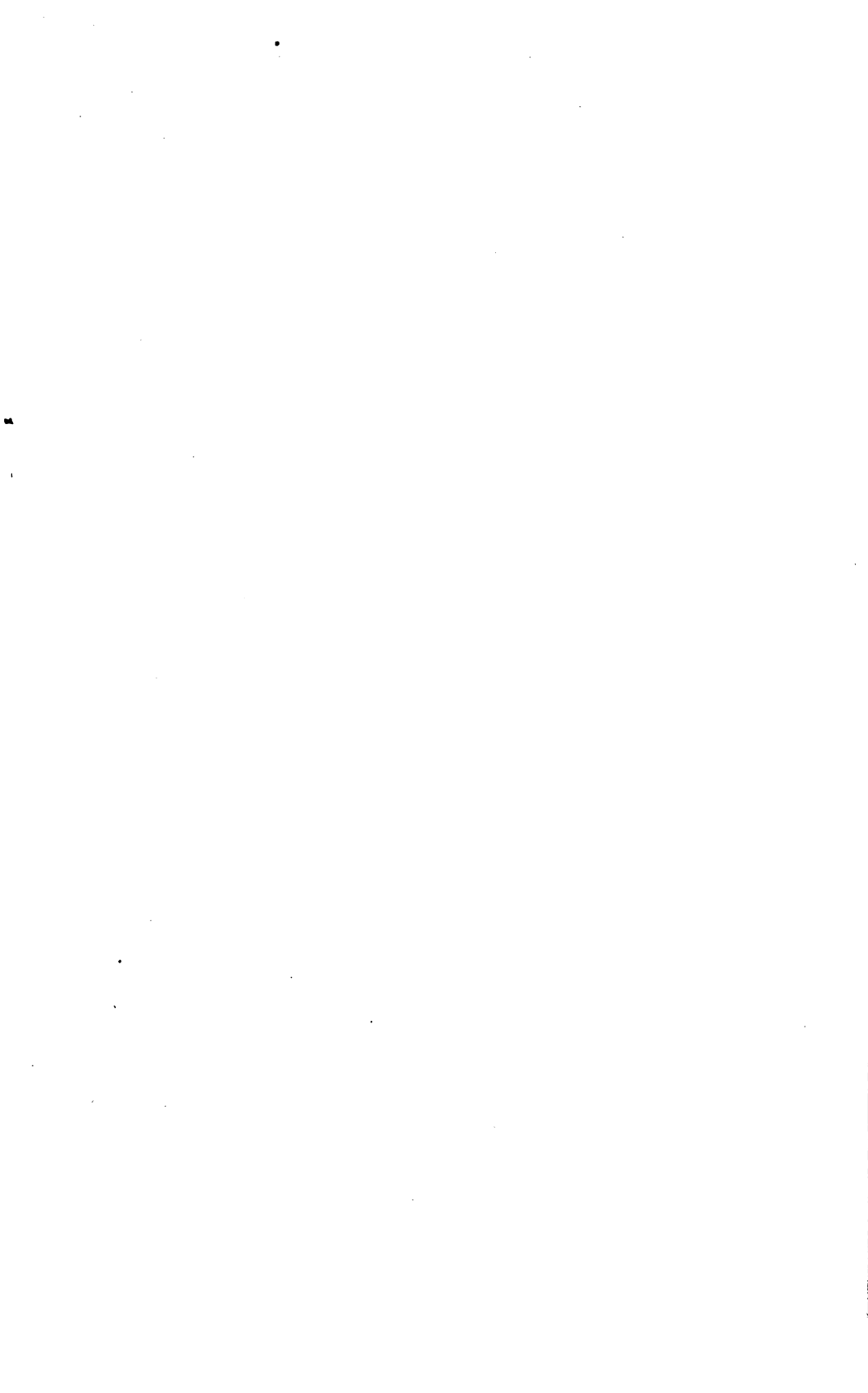
BY

W. J. HUMPHREYS

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1918

CITY OF WASHINGTON
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March, 1919





ried Charlotte Colgate, who came of a line of Dissenters registered at Leyden in 1610-1620.

8. CLEVELAND ABBE, 1838-1916, subject of this sketch.

Walter, 1841 —, for many years head chemist of the Atlantic White Lead Works.

William, 1843-1879, died from after-effects of a wound received at Gettysburg.

Charles, 1849-1917, inventor, and for some years an assistant examiner in the U. S. Patent Office.

Robert, 1851 —, eminent surgeon in New York.

Helen, 1853 —, married Hubert Howson of New York.

Harriet, 1855 —, single, New York.

9. Cleveland Abbe, Jr., 1872 —, meteorologist and editor of the *Monthly Weather Review*.

Truman Abbe, 1873 —, surgeon, Washington, D. C.

William Abbe, 1877 —, patent attorney, New York.

10. Several children: of Cleveland, one son; Truman, two sons and two daughters; William, three sons and three daughters.

Professor Cleveland Abbe was born on Madison street, New York City, December 3, 1838, and died at his home in Chevy Chase, Md., October 28, 1916, from effects incident to the malignant degeneration of a mole, which had rapidly become so extensive as to prevent his resting comfortably in other than one position. For more than a year he had also been afflicted with partial paralysis of the right side, but this, from which he had largely recovered, never in any wise affected either his mind or his cheery hopeful disposition nor, apparently, at all hastened the end.

Professor Abbe's preliminary education was obtained, first, in private schools and, later, in the David B. Scott Grammar School, No. 40, on 20th street, New York. His academic training was acquired at the New York Free Academy, now the College of the City of New York, which he entered in 1851, and from which he was graduated with distinction, obtaining the degree B. A. in 1857 and M. A. in 1860..

But this formal education was abundantly supplemented by extensive reading on all manner of subjects. Nor did he ever lose his interest in every branch of human knowledge, nor

cease to read, or at least desire to read, everything printed that by any chance could be worth reading. In reference to this characteristic an admiring friend, writing of him as he knew him in his later life, says:

"From the first I was impressed with his broad interests, extending not only outside of meteorology and astronomy to the other sciences, but to philosophy, art, and literature. His knowledge was very broad; his reading comprehensive. I remember, when living at his home, seeing him very early in the morning sitting in his library reading the *Encyclopedia Britannica*. He told me that he was reading it through consecutively."

During his school days he had the advantage of spending his summer vacations in the country with his grandfather, Moses Cleveland Abbe, near Windham, Conn. On these occasions the future meteorologist, it is said, sometimes found it more pleasant to loll in the shade and contemplate on the beauty and mysteries of the floating clouds than to help his worthy ancestor with the exacting duties of the farm. But the youthful dreamer was ever subject to the old gentleman's wholesome admonition to the effect that "boys that don't work don't eat," and so it happened that these summer vacations furnished both healthful exercise and abundant opportunity to get acquainted with many natural phenomena of absorbing interest.

Early in his life, indeed when he was only eight years old, there happened a trivial occurrence which perhaps should be recorded, as it seems to have had an important influence on his entire intellectual career. This was the gift to him by his mother of "*Smellie's Philosophy of Nature*," a remarkable book by the editor and in great part author of the first edition of the *Encyclopedia Britannica*. This he pored over as a boy, kept sacred in his library throughout the whole of his active career, and so frequently and feelingly alluded to during his last illness that in loving tenderness it was placed in his hands as a fit companion during his long rest beneath the oaks and the roses of beautiful Rock Creek Cemetery.

Professor Abbe was twice married and on each occasion most happily. His first marriage, May 10, 1870, was to Miss Frances Martha Neal, daughter of David Neal of Cincinnati.

Practically all their wedded life, terminated by death on July 24, 1908, was spent in that historic old mansion, once (1817) the "White House," 2017 I Street N. W., Washington, D. C. which they owned, where they entertained their numerous scientific and other friends, and where, dearest of all to them, they reared with every thoughtful care their three sons, Cleveland, Jr., Truman, and William.

His second marriage, April 12, 1909, was to Miss Margaret Augusta Percival, of Basseterre, St. Christopher, B. W. I., under whose constant care and unfailing devotion the remainder of his useful life was most happily spent.

In religion Professor Abbe was always devout and sincere, and saw only the good in every Christian creed. Though a member of the Baptist Church from the age of 15, and devoted to its earnest simplicity, he nevertheless loved the beautiful ritual of the Episcopal Church, in which, especially during his later years and in company with his second wife, he frequently found inspiration and comfort. To him form in religious worship, apart from its æsthetic appeal, was of small matter, so long as the sincerity and the substance were the same.

As already stated, Professor Abbe was graduated from the New York Free Academy (College of the City of New York) in 1857. During 1857-'58 he was tutor of mathematics, a subject of which he was very fond, in Trinity Latin School, New York. The following year, 1859, he was an assistant professor of Engineering in the Michigan Agricultural College; and later, 1859-'60, tutor in Engineering at the University of Michigan, where he found in Professor Brünnow an inspiring instructor in Astronomy, the Science whose marvelous revelations had, above all others, aroused and directed his youthful aspirations.

Near the close of his year at Ann Arbor stern duties arose, and Abbe responded in April, 1860, to Lincoln's first call for volunteers. For a few weeks he was tried out at a recruiting camp, but finally, to his severe disappointment, rejected because of excessive myopia, an affection that debarred him from youthful games, forbade him a soldier's service, and all his life long restricted his pleasures and limited his opportunities. Though rejected as a soldier he nevertheless served

his country during the years 1860-'64 by assisting Dr. B. A. Gould at Cambridge, Mass., in the telegraphic longitude work of the United States Coast Survey. Presumably it was this practical work with Dr. Gould that led to his spending the next two years, 1865-'66, as a guest or supernumerary astronomer at the Observatory of Pulkova, near Petrograd, noted for its contributions to applied astronomy, and then under the direction of the famous Otto Struve. Here he found not only congenial work but also pleasant companions and the good cheer of warm hospitality. In this happy atmosphere his sympathetic nature found such peace and content as to cause him always to remember Pulkova as a scholar's paradise!

On his return to the United States Professor Abbe accepted, in 1867, the position of aid in the U. S. Naval Observatory; but shortly afterwards, on February 1, 1868, assumed the responsible duties of director of the Cincinnati Observatory, to which he began giving his entire time on the 1st of June. The inclusiveness of his plans on taking charge of this observatory was set forth in his inaugural report, June 30, 1868, to the Board of Control, in which he says:

"If the director be sustained in the general endeavor to make the observatory useful, he would propose to extend the field of activity of the observatory so as to embrace, on the one hand, scientific astronomy, meteorology, and magnetism, and, on the other, the application of these sciences to geography and geodesy, to storm predictions, and to the wants of the citizen and the land surveyor."

This generalized plan he then elaborated into a scheme, magnificent in scope and noble in purpose, but out of all possible proportion to a one-man observatory whose chief function hitherto had been that of entertaining the public. His disposition always was so hopeful that, apparently, he seldom took into consideration such obstructive factors as lack of time or want of opportunity. But if, perhaps, this accounts for his beginning some things that were never completed, it doubtless, on the other hand, also accounts for the completion of many things that otherwise might never have been begun.

During his directorship of the Cincinnati Observatory, however, Professor Abbe's active interests, in spite of his all-inclusive program, soon turned more and more to meteorology, and

especially to that eminently useful application of it by which warnings may be given of approaching storms. He was much interested in the fact that telegraphic circuits were then generally made up so as, presumably, to be least disturbed by storms as indicated by the morning reports from many stations, of the weather, height of the barometer and direction of the wind. This demonstration of the value and practical use of weather predictions aroused in him an impatient desire, born of earnest conviction, that the great benefits of storm and flood warnings be extended to the entire public and all its industries. Accordingly, on July 29, 1868, he addressed the following letter to the president of the Cincinnati Chamber of Commerce:

"Mr. JOHN A. GANO,
President, Cincinnati Chamber of Commerce.

"DEAR SIR: I take the liberty of bringing to your attention, and through you to that of the Associated Press, a plan of operations looking to a system of storm warnings such as will, I believe, be highly appreciated by the public.

"It cannot have escaped your notice that during the past 20 years very many endeavors have been made by various nations to utilize the science of meteorology. From the Paris Observatory daily bulletins are published showing the state of the weather in western Europe. In England storm warnings are published many hours in advance and sent to the ports that are threatened.

"The great value of such storm warnings long ago suggested the importance of the study of the phenomena of our own climate, and these labors have met with commensurate success. But such endeavors must be long continued and not spasmodic, and in view of their importance I take the liberty of suggesting a simple plan by which the Associated Press may contribute much towards the progress of the science of meteorology as well as towards its utilization.

"The Cincinnati Observatory, because of its central position with reference to the railroad and the telegraph systems of our country, may with special propriety be made the central station for meteorological dispatches from all parts of the country. The newspapers daily publish such dispatches from ten to fifty stations, and it is suggested that if the Associated Press will substitute for these far more accurate and valuable observations of the trained meteorological observers stationed all over the country, and will forward them to this observatory, we will submit them to a careful discussion, and will within a few hours return them systematically arranged and condensed to the Associated Press. In this shape they will be of increased value to all who consult them.

We shall, moreover, ourselves enter these observations upon an appropriate manuscript chart, and propose that when we send the daily digest of the weather to the Associated Press we accompany it with such general predictions of the weather for the next two days as we may seem authorized to venture upon.

"It seems certain that, at least in the case of a great storm, we may arrive at a greater degree of certainty in these predictions than is attained in England and France, where only three-tenths of the predictions are verified.

"Such a system as we propose would, it is believed, powerfully contribute to advance science and practical meteorology.

"We have received promise of the hearty coöperation of the observers of the Smithsonian Institution and of the army in case the systematic daily publication of good observations and storm warnings is attempted.

"To render these meteorological reports as simple and brief as possible consistent with accuracy, a series of blanks will be issued to each observer, who will each day at an appointed minute (8 a. m., Cincinnati mean time) record the following data:

"a. Barometer reduced to 2 degrees and to a common standard.

"b. Temperature of the free air.

"c. Amount of moisture in the free air.

"d. Direction and force of the surface wind.

"e. Quantity of lower clouds, kind, and direction of motion.

"f. Quantity of upper clouds, kind, and direction of motion.

"g. Amount of rain or snow during the past 24 hours.

"h. Condition of the atmosphere (clear, hazy, foggy, etc.).

"Further instructions will be given to the observers by which the dispatches from each will average twenty or twenty-five numbers or letters. Observers of the requisite experience can readily be found in all desired localities. They should be distributed widely over the country. If not found at any desirable place, then the telegraph office at that point will be supplied with the proper instruments, and some employee of the company instructed in their use, the company being responsible to the extent of \$100.00 for the value of the instruments. The observers will send their blanks to the nearest telegraph office addressed to the 'Cincinnati Observatory,' and we must receive them all at the Cincinnati office of the Western Union Telegraph by 12 o'clock noon. Should there be no communication with any station, we are to be informed of the fact, and the delayed dispatches are to be forwarded at the earliest opportunity. These dispatches are to remain and be the property of the Cincinnati Observatory. The observers will furnish their observations gratis, receiving in return a copy of the daily bulletin or summary in a form convenient for preservation.

"The daily digest and the weather predictions are to be furnished by the Cincinnati Observatory gratis to the Associated Press and to such

institutions as unite with us in our undertaking. At least 100 stations ought to be thus occupied and report daily. If the Associated Press will assume the expense of 50 daily dispatches, it will not be difficult for us to secure the coöperation of other interested parties who will afford the means of largely increasing the number of daily dispatches.

"Hoping that this or some improved plan may commend itself to your attention,

"I remain very respectfully yours,

"(Signed)

CLEVELAND ABBE,

"Director Cincinnati Observatory."

After much consideration of this proposition Mr. Gano requested Professor Abbe to send him a second letter that could be presented to the Cincinnati Chamber of Commerce. The following is a copy of the "rough notes" of the second letter, and Fig. 1 is from a photographic copy of the sketch referred to, which, however, is not in Professor Abbe's handwriting:

"CINCINNATI OBSERVATORY, May 7, 1869.

"JOHN A. GANO, ESQ.,

President, Cincinnati Chamber of Commerce:

"As the changes in the weather have so important a connection with many branches of business, and especially with agriculture and navigation, it has by many been considered very desirable that the science of meteorology should be utilized by attempting to draw therefrom some predictions as to the state of the weather in the future. In order to meet this want, I propose to inaugurate such a system by publishing in the daily papers a weather bulletin which shall give the probable state of the weather and river for Cincinnati and vicinity one or two days in advance.

"These predictions will be based upon a system of telegraphic dispatches received from proper observers stationed at various distances from the city, and the accuracy of the predictions, etc., will increase from month to month and year to year, in proportion as we are able to increase the number of our stations. For many years a system of storm predictions has been kept up in France and England, and this has, during the past three years, been extended with great success to India. This system is under the special care of the British Board of Trade, and is recognized as of eminent usefulness, the predictions failing only in a small percentage of the cases. As Cincinnati is very favorably situated with respect to the proposed outlying stations, it is most probable that 90 per cent of our weather predictions will be verified. It is thus evident that we do not propose to guess at the weather, but (leaving that to the almanac makers) we shall be able to assert with confidence the nature of the weather for one, two, or four days in advance, as well as the stand of the water in the river.

Albuquerque

Del Rio
425

Chicago
250

St. Louis
250
Tulsa
200

Chattanooga
275

Buffalo
400

Omaha
650

Some

Dallas
200

St. Paul
550

Lawrence, Mo.
550

St. Louis
300

Cincinnati

Abilene
225

Carroll
275

Marshall
225

Memphis
400

Chattanooga
300

Vicksburg
575

Selma
475

Sample dispatches

Barometer reduced to 32° — 29.372

Dry therm — 53.3

Wet therm — 48.14

rainy rainfall } no rain
snowfall }

Clouds lower

time

cumulus

Dec

N. E

upper lines

air

3

W

Wind direction

N. E

force

3

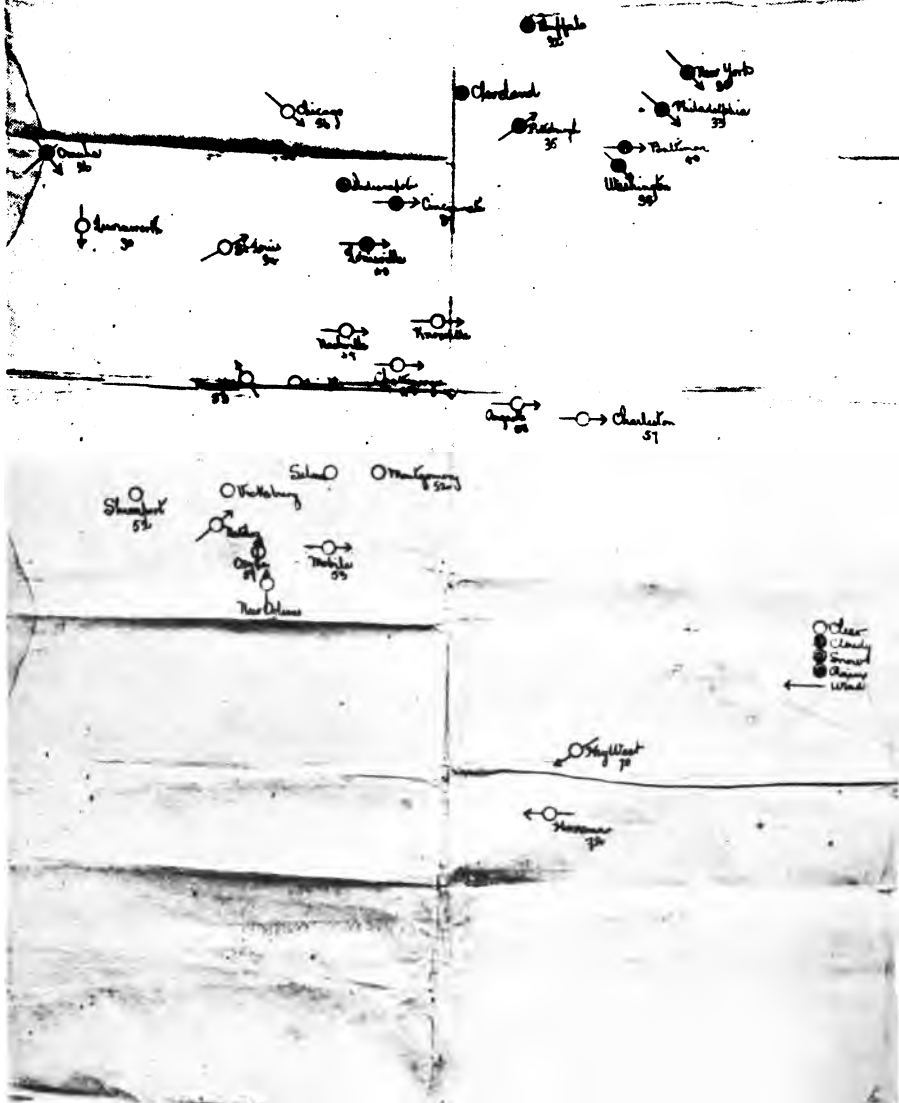
Time when storm began

whether the weather turned
with rain or.

Total average 2.5 records.

Western Union Telegraph Co. Weather Report

Monday February 2nd 1897



"The expense of the proposed system will arise in the first place from the furnishing of the stations with instruments and the cost of the telegraphic dispatches, and again in the method of publishing the predictions. As to the former, the furnishings for the stations, in order to inaugurate the system, will be \$500; the telegraphic dispatches, per year (365 x 10, at 25 cents), \$900; the total will not exceed \$750 or \$1,000.

"Should the Chamber of Commerce support this undertaking, it would be very proper that besides the publication in the morning papers there should be hung up in the Exchange a chart of the country, showing at a glance the condition of the weather at a given moment."

This copy is without signature being attached. A notation by Professor Abbe says:

"The original draft adds a sketch of twenty stations, and a sample form of telegraphic dispatches, estimated to not exceed twenty-five words, but I am not sure that these were sent to Mr. Gano in this letter. They were submitted to the committee of the Chamber of Commerce a few days afterwards."

The immediate results of this appeal are best told by the following quotation from Professor Abbe's report of June 18, 1870, to the Board of Control of the Cincinnati Observatory:

"The importance of anticipating the changes in the weather, especially storms or droughts, was alluded to in my report of June, 1868. This subject having been brought by myself to the attention of the Chamber of Commerce of this city, that body, in June last [1869], authorized me to organize a system of daily weather reports and storm predictions. Experienced observers at distant points offered their gratuitous coöperation. The Western Union Telegraph Company offered the use of their line at a nominal price. The bulletin began to be issued September 1, in manuscript form, for the special use of the Chamber of Commerce, and began to be printed a week later as an independent publication.

"This bulletin was supported for three months, as at first agreed on, by the Chamber of Commerce; its conduct then passed entirely into the hands of the observatory, and has thus continued until the past month. The independent publication of the bulletin was, however, discontinued, and it has, since December 1, only appeared in the morning papers. The daily compilation of this bulletin for the newspapers was undertaken two weeks ago by the Cincinnati office of the Western Union Telegraph Company, and will so continue, thus relieving the observatory of all further responsibility.

"In February the manager of the Cincinnati office undertook the publication of a daily weather chart [Fig. 2 is a copy of the chart for

February 28, 1870], and the favor that this has met with insures its continuation in the future. The Daily Weather Bulletin and Chart are, therefore, now supported solely by the Western Union Telegraph Company, and must be considered as a very important contribution to meteorology. It would have been highly to the credit of the observatory could these publications have been maintained in its own name; but this was impossible, owing to the want of funds and assistants."

The bulletins for September, October, and November, 1869, were prepared by Professor Abbe, written on manifold paper by clerks in the Western Union Office and delivered by the messengers, and known as "greasers."

Professor Abbe's justifiable enthusiasm over his success in foretelling the coming of storms may be inferred from a letter to his father in which he said: "I have started that which the country will not willingly let die."

This statement did not refer, of course, to the collection of meteorological data, nor to the construction from telegraphic reports of maps showing the current state of the weather over the country, both of which had been done by the Smithsonian Institution under the direction of Joseph Henry some 20 years earlier, but rather to the systematic daily forecast from such maps of the *coming* weather. And his estimate was correct, for the time was so ripe for a National Weather Service that less than six months after the first Bulletin of the Cincinnati Observatory was issued, the Federal Government through a Congressional resolution signed by the President February 9, 1870, authorized the creation of a Weather Service, and placed it under the immediate direction of the Signal Service.

On putting this law into operation the Secretary of War sought the services of Prof. I. A. Lapham of Milwaukee, Cleveland Abbe, then of Cincinnati, and others. Professor Lapham, through his persistent advocacy of storm warnings for the benefit of commerce on the Great Lakes, had been influential in securing the Federal action that established a National Weather Service. Therefore, and also because of his knowledge of the subject, he was offered the position of Assistant to the Chief Signal Officer at Washington. Private considerations, however, kept him from coming to Washington, but he did consent to act for a time in this capacity at Chicago.

Professor Abbe, the only man in the country who, before the establishment of this Service, had had experience in practical weather forecasting for the public, was then appealed to, and finally consented to serve in the position Lapham had been unable to accept, beginning on January 3, 1871. At first he had expected to resign at the end of three years, the term of his appointment, but instead of doing so he continued in this Service without interruption, through various trying circumstances, until June 4, 1915, when, owing to ill health, he took a year's furlough. Being still unable to assume regular duties, he resigned on August 3, 1916. During about half of this time, or from August, 1893, his principal work had been the extremely useful and congenial one of editing the meteorological journals of the Weather Bureau—the *Monthly Weather Review* and the *Mount Weather Bulletin*.

The following delightful story of Abbe's connection with the Weather Bureau during its formative period has been put at my disposal by Prof. T. C. Mendenhall. It is given in its entirety because of its general interest, and also because it covers the most active period of Professor Abbe's career:

"Although the years of my acquaintance with Professor Abbe were nearly fifty in all, my intimate association with him began about a third of a century ago. It was in the 'early eighties' of the last century, when the Weather Bureau was the Signal Corps of the Army or the Signal Corps was the Weather Bureau, both modes of stating the relation of the two being essentially correct, as for many years the operations of the Signal Corps were practically restricted to its activities as a weather forecasting service. In order to understand and appreciate the almost unique combination of qualities, moral and intellectual, which enabled Abbe to play his great part in the creation and development of what is in many respects the most important of the scientific bureaus of the Government, it is necessary to know something of the conditions under which he worked during the earlier stages of that development.

"At thirty years of age, as the enthusiastic director of the Cincinnati Observatory, he had successfully inaugurated a system of weather reports by telegraph from which daily forecasts were attempted. His success led to an act of Congress providing for the utilization of the Signal Corps of the army for the organization of a general weather service, and Professor Abbe was called to Washington as meteorologist in that service. At that time he was the only man in the country having experience in or knowledge of weather forecasting for the use of

the public based upon the principles of scientific meteorology, and for some time the duty of daily interpreting the meteorological observations made in all parts of the country devolved upon him alone. The new service was immediately popular, and though barely thirty years of age, he soon became generally known as 'Old Probabilities,' or 'Old Prob.' Realizing that the then state of our knowledge of meteorology was quite inadequate for anything like accurate forecasting, he sought to induce the War Department to obtain an annual appropriation for the purpose of maintaining a systematic study of the subject, both theoretical and experimental. Methods of transacting business assumed to be necessary in a military organization in time of peace are decidedly inimical to scientific investigation and research, and from the start Abbe's plans met with obstruction at almost every turn, not always due to unfriendliness—indeed, more often to mere inertia of the system. In overcoming this opposition, which at times was so unyielding as to completely discourage all others who were interested, he was successful, because his two most characteristic traits were an inexhaustible enthusiasm for the work, which amounted almost to an obsession, and an equally inexhaustible patience in meeting unfriendly or unintelligent criticism.

"I think not much was actually accomplished until Gen. W. B. Hazen became Chief Signal Officer in 1880. For the two great advances made during the first few years of his administration credit belongs to Abbe, almost if not quite alone. Certainly the initiative and general plans were his, though, of course, there could have been no success without the friendly support of the Chief Signal Officer. Perhaps the most important of the two was the improvement of the character of members of the corps by means of a provision for special enlistment of young men, mostly college graduates, with the rank of sergeant in the Signal Corps, with exemption from most of the ordinary duties of the regularly enlisted soldier.

"The other was the establishment of what was known as the 'Study Room,' in which all meteorological problems arising in the service were subjects of investigation by civilians employed for the purpose, two or three of whom had the rank or title of 'Professor' and some others that of 'Assistant Professor,' an arrangement probably suggested by the practice of the military and naval academies. This was shortly supplemented by the establishment of a laboratory for experimental investigation, the inauguration of which I undertook at the earnest solicitation of Professor Abbe in 1884.

"The study room and the laboratory formed, also, a sort of school for the enlisted men, to whom courses of lectures on meteorological, physical, and allied topics were given. The distinguished meteorologist, William Ferrel, was one of the professors, and in addition to a part in the instructional work his assignment embraced a theoretical investigation of the general principles of meteorology with a view

to the improvement of the work of forecasting the weather. The vitalization of the service through these important changes resulted, happily, in the acquisition of such young men as Marvin, Fassig, McAdie, Morrill, McRae, Russell, and a number of others, some of whom are still in the service, and from several of whom have come in later years contributions to the science of meteorology of very great value.

"The difficulty of doing scientific work, either theoretical or experimental, under conditions then existing, can be appreciated only by those who have attempted it, and it is because of Professor Abbe's extraordinary courage and success in meeting these difficulties that I am referring to them at such length. There was at that time a sort of a tradition among military men—which may not yet be extinct—implying that a properly signed written order from a superior officer to do a certain thing carried with it not only the duty of doing it, but also the *capacity* to do it, which I imagine may be a rather stimulating idea for one engaged in battle, though of doubtful value in scientific research.

"Our duties were assigned to us in regular instructions or 'orders' from the Chief Signal Officer, written on regulation order slips on which our initials were placed, as evidence that we had received and understood our instructions.

"The headquarters of the Signal Corps were at that time on 'G Street,' near the War Department, and by a curious chance the two somewhat conflicting elements were housed on opposite sides of the street, the study room, the laboratory, the instrument testing division, etc., being in one building on the south side, while the offices of the Chief Signal Officer and his military aides, the property and disbursing officer, the forecasting officers, etc., were on the north. That controversies between the two were on the whole rather infrequent and rarely acute was due, more than to anything else, to Abbe's unfailing good nature and general willingness to be the subject of the obloquy of both sides.

"The military tradition I have referred to above did not harmonize with the traditions and practice of scientific research. The most industrious and enthusiastic investigator would be somewhat dismayed by the receipt of 'instructions'—not much unlike the following: 'You will begin on Monday next an investigation of the cause or causes of the attraction of gravitation, and make a preliminary report upon your work in two weeks. A final report is to be ready by the first of next month.' Unfortunately Nature does not yield her secrets in response to orders, and there were naturally many failures to 'get results' on time. For example, to Abbe was assigned the preparation of a text on the general subject of meteorology, and his failure to produce a certain number of pages in a given time would be the subject of much fault-finding from 'across the street,' where it was often thought that the study room was not 'paying its way.' The Chief Signal Officer, General Hazen, although first of all a soldier from the time of his admis-

sion to the West Point Military Academy to the day of his death, was by no means unfriendly to scientific men and their work. His attitude was frankly one of open-mindedness, desiring only, like the traditional Missourian, to be 'shown.' But it was not always easy to show him that, although nothing tangible had been accomplished during the past month, the time had not been wasted. He had great confidence in and admiration for Professor Abbe, consulted him freely, and was often guided by his advice when it did not agree with that of his military aides. But in spite of this fact, occasionally when some one would succeed in convincing him that there was too much unproductiveness across the street, he would call Abbe, and, according to an 'office legend,' after emptying the vials of his wrath upon him, would immediately send an official note to the Secretary of War recommending an increase in his salary. In the offices having charge of the disbursement of funds, and of the 'property' of the service, there was little sympathy with the work across the way, and great discouragement to those engaged in it was often the result. The amount of 'red tape' that had to be unwound before the smallest expenditure could be made, together with the fact that the necessity for such expenditure must be shown to an officer quite ignorant of the nature of the work, whose merit was measured by the expenditures he prevented, was often extremely disheartening, and, in fact, it is correct to say that the scientific work of the Weather Bureau was at that time almost continually on the defensive, existing only on sufferance. Indeed, this was in some degree true of all the other so-called scientific bureaus of the Government. Happily it is a condition that has now almost, though not yet entirely, disappeared.

"Certainly if the workers in the study room and in the laboratory were not kept busy enough, it was no fault of Abbe's. He had a singularly full and complete knowledge of the state of the science of meteorology in all parts of the world, and was continually suggesting problems that he thought demanded attention. He usually made a short visit in the laboratory every day, and it was humorously regarded as a disappointment when he did not bring us at least one new subject for experimental investigation. One of his most outstanding traits was the absolute absence of anything like envy or jealousy in his relations with his fellow-workers and scientific men generally. He was quick to recognize a meritorious performance or a meritorious person, and, generous in praise as he was, also at times free in criticism. His disposition was most amicable; he was one of the most lovable men that I have ever known. There was a rare simplicity and frankness in his speech which was reflected in his acts, and added much to the charm of his personality. One could always feel sure that there was no *arrière pensée*; but he was most considerate for the feelings of others, and never intentionally wounded by word or deed. During his long career in the service of the Government, covering nearly half a century,

he passed through many trying situations. The work in which he was engaged was more than once 'under fire,' but passing years have only emphasized the importance of that work with a more general recognition of our great indebtedness to Abbe as the real founder.

"When one considers the small beginning in 1869 at the Cincinnati Observatory, with a few daily telegrams generously donated by the Western Union Telegraph Company, a local forecast printed in a single daily newspaper, and then turns to the present splendid organization, with its thousands of observers, its two or more daily forecasts printed in every city and town, and reaching by telephone or otherwise the remotest corners of the country, its storm warnings, its frost and flood warnings by which annually property worth many millions of dollars is saved from destruction, its important investigations in the field of agricultural meteorology and its other useful functions, one cannot avoid the conclusion that the nation has had few more useful servants than Cleveland Abbe."

Of the many useful rôles Professor Abbe played in the drama of his day perhaps on the whole the most serviceable were those of mentor and propagandist. For years he took a prominent part in the agitation for a system of standard time that finally led to the present compromise of partial order. He also urged the establishment of climatological and meteorological services by the individual States, and had the pleasure of seeing many of them adopt his suggestions. In aid of the student all that was then known of meteorological instruments and methods was compiled in one convenient and invaluable manual; a bibliography of meteorological literature was begun and in great measure completed, and the best papers on dynamical meteorology assembled in two volumes—*The Mechanics of the Earth's Atmosphere*. Finally, by conversation, publication, translation, and countless private letters, he strove, and effectually, to create an active interest in the science of meteorology, and to enlist in the solution of its innumerable problems students of the research type—keen of intellect and persevering. The persistence of his efforts to this end and their eminent success are well described by Prof. R. De C. Ward, of Harvard University, who says, in part:

"I remember Professor Abbe as always keenly interested in the work and progress of young men who were looking towards meteorology, either as a career or only as a passing subject for study. He must have written hundreds of letters of the kind that he often wrote to me,

giving encouragement, suggestion, help. I wrote him once, at the beginning of my own professional career, when I was greatly discouraged and about to turn in some other direction for a livelihood. Professor Abbe wrote me a letter so full of encouragement, urging me so strongly to 'stick to my job,' and assuring me that all would come right in the end, that I gave up my idea of abandoning meteorology. I think Professor Abbe's letter was really one of the turning points in my life.

"Professor Abbe was always keenly and actively interested in promoting sound meteorological education, especially along mathematical and physical lines. He used to write me long letters, outlining problems for young meteorologists, and urging me to establish a school of meteorology, where experts could work together on various atmospheric problems. These schemes of his always seemed most highly visionary to me, but I enjoyed the enthusiasm of Professor Abbe's letters and found a stimulus in them.

"I found Professor Abbe ready at all times to answer any questions, no matter how much time these answers might require. I wrote him freely for years, and I spent many hours trying to decipher that highly characteristic and almost illegible handwriting of his. But this time was well spent, for he never sent me a letter that did not contain something of distinct value and help.

"The qualities which, I think, impressed me most were his wonderful patience; his enormous fund of all sorts of meteorological knowledge; his never-failing willingness to help every one who came to him for information or advice; his modesty in everything that concerned his own accomplishment; his splendid enthusiasm and his desire to impart that enthusiasm to all his fellow-workers in meteorology."

Naturally many honors came to Professor Abbe, two of which, the Symons Memorial Gold Medal, bestowed by the Royal Meteorological Society of Great Britain, in 1912, and the Marcellus Hartley Medal, awarded by the National Academy of Sciences, April 18, 1916, were of inestimable value to him, typifying respectively, as they did, eminent success in his chosen science, and in its application to human welfare.

As just stated, his honors were many; so also were the positions of trust he held and the learned societies of which he was a member. Similarly the causes of these honors—the papers and the memoirs he wrote—are exceedingly numerous. Ordinarily it would be difficult now to obtain a full list of all these honors, societies, et cetera, and well nigh impossible to compile a complete bibliography. But here again Professor Abbe's methodical care is of great service, and therefore the

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following lists, and the accompanying selected bibliography, kindly made up by Dr. Cleveland Abbe, Jr., from his father's abundant notes, are submitted with the belief that with the exception of numerous editorial comments, but little of importance has been omitted.

COLLEGIATE DEGREES HELD

- 1857. B. A., Free Academy, *now* College of the City of New York.
- 1860. M. A., Free Academy, *now* College of the City of New York.
- 1889. LL. D., University of Michigan (honorary).
- 1891. Ph. D., College of the City of New York (honorary).
- 1896. LL. D., University of Glasgow, Scotland (honorary, on occasion of Lord Kelvin Jubilee).
- 1900. S. B., "as of 1864," Harvard University, Cambridge, Mass.

COLLEGIATE POSITIONS HELD

- 1857-58. Tutor in Mathematics, Trinity School, New York, N. Y.
- 1859. Assistant Professor of Engineering, Michigan State Agriculture College, Lansing, Mich.
- 1859-60. Tutor in Engineering and Mechanics, University of Michigan, Ann Arbor, Mich.
- 1884-1916. Professor of Meteorology, Corcoran Scientific School, Columbian (George Washington) University, Washington, D. C.
- 1896-1916. Lecturer in Meteorology, Johns Hopkins University, Baltimore, Md.

OFFICIAL POSITIONS HELD

- 1860-1864. Aid in U. S. Coast and Geodetic Survey (doing astronomical work at Cambridge, Mass., under B. A. Gould).
- Dec., 1864-May, 1865. Resident guest at Nicholas Central Observatory, Pulkova, near Petrograd.
- May, 1865-Sept., 1866. Ausserétatmässiger, or Supernumerary Astronomer at Nicholas Central Observatory, Pulkova, near Petrograd.
- 1867-68. Aid at U. S. Naval Observatory, Washington, D. C.
- 1868-73. Director, Cincinnati Observatory, on Mt. Adams.
- 1871-91. Professor of Meteorology and Civilian Assistant in the office of the Chief Signal Officer, U. S. Army.
- 1891-1916, Aug. 4. Professor of Meteorology in the U. S. Weather Bureau, Department of Agriculture.
- 1892-1909, July. Editor of *Monthly Weather Review* of U. S. Weather Bureau.
- 1909, May-Oct. Official in Charge, Local Office Weather Bureau, at Baltimore, Md.

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- Oct., 1909-1913. Editor of *Mount Weather Observatory Bulletin*, various residences.
 Jan., 1914-1916, Aug. 4. Editor of *Monthly Weather Review*.

MEMBERSHIP IN COLLEGE FRATERNITIES

- 1856-1916. Member of "Alpha Delta Phi," Manhattan Chapter, Class ['57 ?].
 1896-1916. Member of "Phi Beta Kappa," New York Gamma Chapter, Class —.

MEMBERSHIP IN SCIENTIFIC AND LEARNED SOCIETIES

1864. Boston Society of Natural History, a member.
 1867. Deutsche Astronomische Gesellschaft, Mitglied [commuted for life].
 1868. New York Lyceum of Natural History, now the New York Academy of Sciences. Corresponding member.
 1868. American Association for the Advancement of Science, Fellow.
 1868. Cincinnati Literary Club, a member.
 1869. Historical Society of Ohio, a member.
 1871. American Philosophical Society of Philadelphia, a member.
 1871. Philosophical Society of Washington, a member and founder. Treasurer and Editor of its *Bulletin*, 1891-1896. President, 1906.
 1874. Oesterreichische Gesellschaft für Meteorologie (Vienna). Mitglied [commuted for life].
 1874. American Meteorological Society (New York), a member.
 1875. Association Française pour l'avancement des Sciences, a member [commuted for life].
 1875. American Geographical Society (New York). Corresponding member.
 1876. Royal Astronomical Society (London), Fellow [commuted for life].
 1879. National Academy of Sciences of the United States of America. member. Hartley medalist, 1916.
 1881. Victoria Institute of Great Britain (London), Associate of.
 1881. New York Historical Society, Resident life member [commuted].
 1882. American Forestry Association, a member.
 1883. Deutsche Meteorologische Gesellschaft (Berlin). Korrespondierender Mitglied. [See 1892.]
 1884. American Academy of Arts and Sciences (Boston). Associate fellow.
 1884. New England Meteorological Society, a member. [Society dissolved in 1896.]
 1887. British Association for the Advancement of Science. Corresponding member; also life member [commuted].
 1888. National Geographic Society (Washington), a member [commuted to life].

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- 1890. American Historical Association, a member.
- 1891. New York Mathematical Society (*now* American Mathematical Society), a member.
- 1891. Royal Meteorological Society (London), a Fellow [later Honorary Fellow and Medalist].
- 1892. Deutsche Meteorologische Gesellschaft (Berlin). Ehren-Mitglied. [See 1883.]
- 1893. Deutsche Mathematische Vereinigung (Munich). Mitglied [commuted for life].
- 1894. Columbian Historical Society (Washington), a member.
- 1895. Société Météorologique de France, a member [commuted for life].
- 1896. Connecticut Historical Society (Hartford). Corresponding member.
- 1897. Societa Meteorologia Italiana (Turin), a member.
- 1898. Washington, D. C., Academy of Sciences, a member.
- 1898. American Institute of Electrical Engineers (New York). Associate member.
- 1899. American Physical Society, a member.
- 1900. Astronomical and Astro-physical Society of America, a member.
- 1902. Carnegie Institution of Washington: Chairman of the Committee of Advisors in Meteorology [temporary position; abolished in November, 1902].
- 1902. Geographical Society of Philadelphia, a member.
- 1905. Association of American Geographers.
- 1913. Seismological Society of America.

MEMBERSHIP IN CLUBS

- Cosmos Club, Washington, D. C., Feb. 5, 1883-Dec. 31, 1884.
- Harvard Club of Washington, 1900-1915.
- Washington Chapter Associate Alumni, College of the City of New York.

DELEGATE TO IMPORTANT CONVENTIONS, ETC.

- 1882. U. S. Signal Service delegate to American Forestry Congress at Cincinnati.
- 1884. U. S. Signal Service delegate to the Electrical Conference at Philadelphia.
- 1884. United States delegate to the International Meridian and Time Standard Congress at Washington.
- 1886. Columbian University (Washington) and Pres. J. C. Welling's delegate to 250th Anniversary of Harvard College.
- 1891. U. S. Weather Bureau associate delegate to 2d International Meteorological Conference at Munich.

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- 1896. Delegate of U. S. Weather Bureau, Columbian University, Kelvin's Baltimore Class of 1884, Kelvin Jubilee (Glasgow).
- 1900. United States delegate to International Congress of Physicists at Paris.
- 1901. College of the City of New York delegate to Bi-centennial of Yale University.
- 1904. U. S. Weather Bureau delegate to inauguration of C. S. Howe as President of the Case School of Applied Science.

DECORATIONS, ORDERS, MEDALS, AND PRIZES

- 1857. Free Academy of the City of New York: Ward Medal in Chemistry [established in 1853]. (Bronze.) Burr Medal in Mathematics [established ? in 1853]. (Silver.)
- 1886. H. H. Warner (Rochester, N. Y.). Medal for Scientific Discovery (gold) for his "Red Light Essay;" see Amer. Metr'l. Jour., April, 1889, 5: 529-544; also *ibidem*, v. 1, p. 454, and v. 3, p. 53.
- 1889. French Republic, Ministry of Public Instructions: "Officier d'Académie."
- 1901. Yale University, bi-centennial medal inscribed, Universitat Yalensis, A. D., MDCCCCI, concelebrat Collegium Yalense, A. D., MDCCI, conditum. (Bronze.)
- 1906. American Philosophical Society (Philadelphia) Franklin medal, inscribed: "Medal struck by the United States Congress to commemorate the 200th anniversary of the birth of Benjamin Franklin (1706-1790). (Bronze.)
- 1907. College of the City of New York: A. Werner memorial, inscribed: "To commemorate fifty years of service at the College of the City of New York. June, 1907. Adolph Werner, Scholar, Teacher, Friend." (Bronze.)
- 1912. Royal Meteorological Society of London: Symons Memorial Medal. (Gold.)
- 1912-13. Franklin Institute (Philadelphia): Longstreth Medal of Merit for his paper, "The Obstacles to the Progress of Meteorology." [See Jour. Franklin Instit., Feb., 1914, 177: 250.] (Silver.)
- 1916. U. S. National Academy of Sciences: Marcellus Hartley Memorial Medal "for eminence in the application of science to the public welfare." (Gold.)

EDITOR FOR METEOROLOGY IN OTHER THAN GOVERNMENT PUBLICATIONS

- 1872-79. Annual Record for Science and Industry (Harper & Bros.). Appleton's New Encyclopedia.
- 1892-94? Johnson's New Encyclopedia.
- 1900-02. New International Encyclopedia (Dodd, Mead & Co.), 1st ed.
- 1913-14. New International Encyclopedia (Dodd, Mead & Co.), 2d ed.

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- 1904-13. Encyclopedia Britannica, 9th ed.
- Encyclopedia Britannica, 10th ed.
- Encyclopedia Britannica, Yearbook "1913."
- 1889. Century Dictionary, 1st ed. ?
- 1905. Century Dictionary.
- 1908-9. Webster's New International Dictionary [1st ed.].

ASSOCIATE EDITOR, ETC.

- 1892-1896. American Meteorological Journal, Ann Arbor and Boston.
- 1904-1916. Beiträge zur Physik der freien Atmosphäre, Strassburg and Leipzig.

SELECTED BIBLIOGRAPHY

1. Solutions of problems in the Mathematical Monthly. American Mathematical Monthly, Cambridge, 1859.
2. Solutions of the general equations of second degree. (Memoir for the degree of A. M., New York City Free Academy, 1860.)
3. The transparency of the earth's atmosphere. Amer. Jour. Science, New Haven, 1864, 2nd series, 38, 28-31.
4. The computation of parabolic orbits; Brünnow's method. Amer. Jour. Science, New Haven, 1864, 2nd series, 38, 79-81.
5. The annual parallax of Sirius from observations at the Cape of Good Hope. Monthly notices, Roy. Astron. Soc., 1866.
6. On the distribution of nebulae in space. Monthly notices, Roy. Astron. Soc., May, 1867.
7. The Repsold portable vertical circle. Amer. Jour. Sci., New Haven, 1867, 2nd series, 43, 207-216, 309-315.
8. Dorpat and Pulkova. Annual Report of the Smithsonian Institution, 1867, pp. 370-390.
9. The portable transit instrument in the vertical of the pole star. *Translated* from the original memoir of Wm. Döllén. With appendix by Cleveland Abbe. U. S. Hydrographic Office, Washington, 1870, p. 8.
10. Inaugural report, 30th June, 1868, of the Director of the Cincinnati Observatory. *Reprinted* in the First Annual Report of the Cincinnati Observatory, Cincinnati, Ohio, May 1, 1869.
11. Circular inviting the formation of the Cincinnati or Western Meteorological Association. In Cincinnati daily papers of July 1, 1868.
12. The Cincinnati Observatory. (Letter to C. A. F. Peters, July 8, 1868.) Astronomische Nachrichten, No. 1707, 1868, 72, 43-44.
13. The resuscitation of the Cincinnati Observatory. Proc., Amer. Assoc. Adv. Sci., Chicago, 1868, 18, 172-174.
14. The meridian line of Ironton, Lawrence Co., Ohio. Ironton register, December, 1868.

15. Determination of the longitude of Ironton, Ohio. Colton's Journal of Geography, April, 1869, 1, 59-60. (Also in Cincinnati Commercial, Dec. 10, 1868.)
16. Memorial to the General Assembly of the State of Ohio: On the county meridian lines and State Surveys: Remonstrating against the proposed law authorizing changes in old monuments. Written, March 5, 1869. Printed March 6, 1869, by State Assembly officially. Columbus, Ohio, March, 1869.
17. Fort Ancient, Warren County, Ohio, Past and Present. Cincinnati Commercial, June 29 (?), 1869. American Naturalist.
18. Annual Report of the Director of the Cincinnati Observatory, May 1st, 1869, Cincinnati, 1869.
19. Results of hourly meteorological observations at Cincinnati Observatory. In the Weekly Bulletin of the Cincinnati Observatory, Cincinnati, July, 1869 to May, 1870.
20. Weekly reports on the activity of the observatory. Weekly bulletin, Cincinnati Obsy., Cincinnati, July, 1869, to May, 1870.
21. On Storm Warnings. An editorial in the Chicago Evening Journal of August 16 or 17, 1869.
22. Letter to Le Verrier at Paris, proposing international exchange of weather telegrams. Bulletin hebdomaire de l'association scientifique de France, August 15, 1869, t. 6, p. 100.
23. First Weather Bulletin for the Cincinnati Chamber of Commerce. Cincinnati, Ohio, September 1, 1869.
24. Weather Bulletins of the Cincinnati Observatory for the Cincinnati Chamber of Commerce. Cincinnati, O., Sept. 1 to Dec. 1, 1869. [Daily weather telegrams and predictions.]
25. Astronomical tables for the Annual Almanac, 1870, of the Cincinnati Gazette. Cincinnati, 1869.
26. Telegraph cipher code for the use of the Weather Bulletin of the Cincinnati Observatory. Cincinnati, Nov. and Dec., 1869.
27. Weather Bulletin of the Western Union Telegraph Co., compiled at the Cincinnati Observatory, Cincinnati, O., Dec., 1869, to May, 1870. [Daily weather telegrams without predictions.]
28. Storm predictions. Letter of January 7, 1870. "The Bureau," Chicago, Feb., 1870, 1, 132.
29. Note on Climatology. Statistical Report of the Secretary of State of Ohio, for 1869. Columbus, 1870, pp. 167-169. [Written in Feb., 1870.]
30. On standard city time. An editorial in the Cincinnati Commercial, March —, 1870.
31. The Greenwich Observatory. Our monthly (C. L. Thompson, Editor). Cincinnati, May, 1870.
32. A point in Egyptian chronology. Monthly Notices, Royal Astron. Soc., London, 1871.
33. Annual Report of the Director, Cincinnati Observatory, June 4, 1870. Cincinnati, 1870.

34. Latitude and longitude of Cincinnati. *Commercial Tribune*, Cincinnati, Oct. 8, 1870; *Colton's Journal of Geography*, New York, Jan., 1871, 1, 92-93.
35. On the connection between terrestrial temperature and solar spots. *Amer. Jour. Sci.*, New Haven, 3rd series, 1870, 1, 345-347; *Nature*, London, June 15, 1871, No. 85, 4, 123.
36. Tri-daily weather predictions, U. S. Signal Service (beginning February, 1871). Washington, 1871, etc. [Published in the name of the Chief Signal Officer, being official work in his office.]
37. An historical note on the method of least squares. *Amer. Jour. Sci.*, New Haven, 3rd series, June 1871, 1, 411-415.
38. Suggestions as to the practical uses of meteorological reports and weather maps. Washington, 1871. 8°. 2nd Ed., 1871; 3rd Ed., 1871; Reprinted in *Annual Report*, Chief Signal Officer for year ending June 30, 1871, as paper 6, on pp. 83-109. Washington, 1871. 8°.
39. Historical notes on the systems of weather telegraphy, and especially their development in the United States. *Amer. Jour. Sci.*, New Haven, 3rd series, 1871, 2, 83-98.
40. Determination of the altitudes of Signal Service stations. Dated December, 1872. [50 copies for distribution.] *See Annual Report* of the Chief Signal Officer for 1873. Washington, 1873, p. 958.
41. Remarks on a table of balloon voyages. *Bull. Phil. Soc. of Washington*, 1871, 1, 38-39. [Analysis of 50 balloon voyages by S. A. King, aeronaut of Philadelphia.]
42. Table for the computation of relative altitudes. *Amer. Jour. Sci.*, New Haven, 1872, 3rd series, 3, 31-34.
43. Observations on the total solar eclipse of [August 7] 1869. *Amer. Jour. Sci.*, New Haven, 1872, 3rd series, 3, 264-267. *Nature*, London, 1872, 5, 367-368.
44. Remarks on the observations of auroras. *Bull. Phil. Soc. of Washington*, Feb., 1872, 1, 45.
45. Structure of the [solar] corona. *Nature*, London, Mar. 7, 1872, No. 123, 5, 367-368.
46. Charts, text, and tables showing some features of the climate of the United States: 1, Temperature of the coldest and warmest week; 2, Isobars and resultant wind movement; 3, Storm frequency. *In Walker's Statistical Atlas of the United States*. Washington, 1874. [Erroneously credited to Lieut. Jackson, under whom was working the draftsman who prepared Abbe's drawings.]
47. Table of differences between local and Washington time for Signal Service stations. *Annual Report*, Chief Signal Officer for 1873. Washington, pp. 960-962. ["My report in minutes and tenths was printed as minutes and seconds."]
48. Table of elevations of Signal Service stations and bench marks.

- Annual Report of the Chief Signal Officer for 1873. Washington, 1874, pp. 950-960.
49. Chronological list of auroras, November, 1871, to July, 1873. Annual Report of the Chief Signal Officer for 1873. Washington, 1874. Appendix 32, pp. 1098-1107. (Reprinted as Addendum to Greeley's chronological list, in U. S. Signal Service Professional Paper No. 3. Washington, 1881, pp. 71-76. 4°.)
 50. Catalogue of auroras observed from 1776-1784 in Labrador. Amer. Jour. Science, New Haven, 1873, 3rd series, 6, 151-152.
 51. Nova Scotia cyclone of August, 1873. Annual Report, Chief Signal Officer for 1873. Washington, 1874, pp. 1025-1034, 6 charts. 8°.
 52. On the dissipation of electricity in gases, by Prof. Demetrieve Bouboulieff. Translation by Cleveland Abbe. Amer. Jour. Sci., Feb., 1874, 3rd series, 7, 118-130.
 53. On the laws governing the movement of storm centers. *Abstract*. Bull. Phil. Soc., Washington, June, 1874, 1, 100-101.
 54. On the positions of the planes of certain nebulae. *Abstract*. Bull. Phil. Soc., Washington, June, 1874, 1, 119.
 55. On the aurora of April 7, 1874, with a chart. Annual Report of the Chief Signal Officer for 1874. Washington, 1874, pp. 383-385, 1 map.
 56. General remarks on the comet. New York *Herald*, July, 1874. On the possibility of the tail enveloping the earth, with the possible result to climate.
 57. Observations on the tail of Coggia's comet (comet No. 3 of 1874). [June and July, 1874.] Dated Oct. 1, 1874. *Astronom. Nachrichten*, 1874, Bd. 84, Col. 353-366.
 58. Letter to Dr. Julius Hann on Ferrel's theory, dated December 29, 1874. *Ztschr. Oesterr. Gesellschaft f. Met.*, Wien, 1875, 10, 93-94. [This letter drew the attention of Hann, Koeppen, and Sprung to Ferrel's works.]
 59. The very much extended nebulae of Sir. John Herschel's "General Catalogue." Amer. Jour. Sci., New Haven, 3rd series, Jan., 1875, 9, 42-46.
 60. On the meteorological theorem of Espy, by Faye. Translated for Journal, Franklin Institute, Philadelphia, Nov., 1875, 70, 348-354.
 61. On the laws of adhesion: Apparent adhesion, by Stefan. Translation of a notice of Stefan's work. Jour. Franklin Inst., Philadelphia, April, 1875, 3rd series, 70, 121-125.
 62. The Bulletin of International Simultaneous Meteorological Observations. Editor and author, 1875-89. [This great organization was official work, published in the name of the Chief Signal Officer.]
 63. The aurora of April 7, 1874. Second Report. In Annual Report of the Chief Signal Officer for 1875. Washington, 1875, pp. 367-374.

64. The aurora of April 7, 1874. Third (final) Report. In Annual Report of the Chief Signal Officer for 1876. Washington, 1876, pp. 301-310.
65. Supplying omission in a closed survey. *The Analyst*, —, 1876, —.
66. (Wind tables relative to the movement of the sand dunes on the coast of North Carolina) in S. T. Abert, "Report on the Survey," Washington, Feb. 21, 1876.
67. Report of the Committee to Collect Information relative to the Meteor of December 24, 1873. *Bull. Phil. Soc.*, Washington, April, 1877, 2, 139-161.
68. Instructions to meteorological observers on the Schooner *Florence*, on the Howgate expedition to Cumberland Gulf. Washington, 1877. (These instructions included a method for determining cloud heights by means of a small balloon.)
69. O[rmsby] M[cKnight] Mitchell's observations of double stars. *Monthly Notices Royal Astron. Soc.*, London, 1877.
70. Short Memoirs on Meteorological subjects. *Translation*. Annual Report of the Smithsonian Institution for 1877. Washington, 1878. 8°, pp. 377-478.
71. On the connection between meteorological phenomena and locust migration. In First Annual Report, U. S. Entomological Commission for 1877. Washington, 1878. 8°, pp. 203-211. (U. S. Geological Survey publication.)
72. The influence of temperature on the hatching of locust eggs. In First Annual Report, U. S. Entomological Commission, for 1877. Washington, 1878. 8°, pp. 423-432. [See also Riley in Second Annual Report, etc., Washington, 1879. 8°, pp. 136-140.]
73. Report of the Chief Signal Officer, predicting the general probabilities for fair observing weather on May 8, 1878, for the transit of Mercury; and on July 28, 1878, for the total solar eclipse. (Dated April, 1878. Lithographed communication to the U. S. Naval Observatory and to the daily press.) [Annual Report, Chief Signal Officer for 1880. Washington, 1881. 8°, pp. 813-818, "Document No. II."]

"This was the first time, to my knowledge, that such extensive long-range forecasts were made and the average verifications were remarkably satisfactory," C. A.
74. Signal Service observations of the transit of Mercury, May 8, 1878. *Monthly Weather Review*, May, 1878. Also Annual Report Chief Signal Officer for 1879. Washington, 1879, pp. 780-782.
75. Present state of meteorology. In Appleton's Annual Cyclopaedia for 1878. New York, Vol. 3, pp. 537-545.
76. Report on observations of the transit of Mercury of May 6, 1878. Annual Report, Chief Signal Officer for 1879. Washington, 1880, pp. 780-782.

77. (First) Report on standard time by Cleveland Abbe, Chairman of the special committee of the American Metrological Society. Proc. Amer. Metrol. Soc. for May, 1879, New York, 1880, 2, 17-44. [The reports of the above committee appeared in Proc. Amer. Metrol. Soc., New York, 1879, 2, 17-29, 174-179, 231-233, 308-311; do., 1882, 27-30; do., 1883, 4, 22-24; do., 1884-5, 5, 52-82.]
78. Conditions on which the Chief Signal Officer co-operates with others in the maintenance of a public standard time ball. Proc. Amer. Metrol. Soc., New York, 1879, 2, 181-183. Reprinted in same, 1883, 4, 53, and as Circular No. 2 of the American Metrological Society. *In* Annual Report of Chief Signal Officer for 1881. Washington, 1882.
79. On standard time. Science News, June 14, 1879.
80. The hatching and migration of grasshoppers. American Naturalist, October, 1880.
81. Climate and diseases. Bulletin, National Board of Health. July 17, 1880, No. 3, 2, 445-447.
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86. Report of the Board on monthly constants for reduction of the barometer to sea level. Dated Feb. 18, 1881. Report of Cleveland Abbe communicating the desired monthly constants, dated May 14, 1881. *In* Annual Report, Chief Signal Officer for 1881. Washington, 1882. Appendix No. 62, pp. 1185-1189. 8°.
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89. Letters and circulars to the governors of the different States, inviting the establishment of State weather services; signed by W. B. Hazen, Chief Signal Officer. (*See* Annual Report, Chief Signal Officer for 1881. Washington, 1882. Appendix No. 73, pp. 1262-1263, and Annual Report for 1882. Washington, 1883. Appendix No. 58, pp. 761-770.)
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91. Preamble and resolutions [on an International Time System] submitted by Gen. W. B. Hazen to the International Geographical Congress at Genoa, September 1, 1881. *Proc. Amer. Metrol. Soc.*, Vol. 2, 289. *Also in* Proceedings of the International Geographical Congress. Venice, 1881. *Also in* Annual Report, Chief Signal Officer for 1881. Washington, 1882. Appendix No. 69, p. 1249.
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99. "Climate and tree growth" (by title), before First American Forestry Congress, Cincinnati, April 25, 1882. [Based on abstract of his measurements of Hough's tree sections.]
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101. Joint resolution of the U. S. Senate and House of Representatives authorizing an international conference on standard me-

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 104. Course of study in meteorology for use at scientific schools. (June, 1883?) Annual Report of Chief Signal Officer for 1884. Washington, 1884. 8°, p. 75. [Transmitted to Brown University.]
 105. (Sixth) Report of the Committee on Standard Time. (December, 1883.) Proc. Amer. Metrol. Soc., 4, 22-24.
 106. Account of the progress in Meteorology in the year 1883. Annual Report, Smithsonian Institution, 1883. Washington, 1884. 8°, pp. 483-569.
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 108. Course of instruction in elementary meteorology for normal schools, and adapted to the 6th and 8th grades of the Washington, D. C., schools. [This was outlined and presented orally to the normal school students; but the fact is merely recorded in Annual Report, Chief Signal Officer, 1884. Washington, 1884, p. 65.]
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 111. a. "First steps towards systematic observations of atmospheric electricity."
 b. "Organization of seismometric observations."
 c. "Methods of verifying weather predictions."
 d. "Barometry and thermometry."
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See Proc. A. A. A. S., Philadelphia, 1884, meeting.
 112. "The Neutral Meridian," address delivered before the International Meridian Conference, Washington, 1884, Oct. 13. [With-

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 120. Effect of wind and exposure on barometric readings. Proc. A. A. A. S., Buffalo, 1886, 35, 120. (Abstract.) Also in Monthly Weather Review, Washington, Nov., 1886, 14, 332; Nature, London, 35, 29-30.
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 122. A correction for gravity in the use of refraction tables. (Dated Aug. 16, 1886.) See Astron. Nachr., Dec., 1886, v. 116, No. 2751, cols. 15-16; also Nature, London, Dec., 1886, 35, 134.
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 125. William Babcock Hazen (Biographical notice). Science, New York, 1887, 9, 331-334; Popular Science Monthly, New York, 1887, 31, 112-117; Nature, London, 1886-87, 35, 541-543.
 126. The general bibliography of meteorology and terrestrial magnetism. Presented to the Manchester meeting of the British Association for the Advancement of Science, August, 1887. See An-

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 132. Recent progress in dynamic meteorology (1885 to 1888, incl.). Annual Report, Secretary Smithsonian Institution, for 1888. Washington, 1890, pp. 355-424. [This contribution included on pp. 403-424, generous portions, the only published ones of a chapter on the prediction of storms and the weather by C. A., which had been prepared and proofed for the suppressed 4th edition of the Signal Service circular, "How to use weather maps."]
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152. Report on the relations between climates and crops. Dated June 27, 1891, addressed to General A. W. Greely, C. S. O. (Published, under Prof. W. L. Moore, Chief of Bureau, as Weather Bureau Bulletin No. 36, Washington, 1905. 386 pp., 8°, but without the statistical tables.)
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167. Charts of storm frequency. *Amer. Met'l Jour.*, May, 1893, 10, 10-12.
168. Needs of meteorology. *Amer. Met'l Jour.*, Apr., 1893, 9, 560-562. (Reprinted in many places.)
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171. Altitude of the aurora. By title before the Philosophical Society of Washington, April 15, 1893. *Also before* the *Amer. Phil. Soc.*, Philadelphia, Jan. 7, 1898. Printed in full in *Terrestrial Magnetism*, Baltimore, 1898, 3, 1-178. (Review by Lockyer in *Nature*, June 8, 1899.)
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173. The formation of rain. *Bull. Phil. Soc.*, Washington, May 13, 1893. (Title only.) (Published in full. See No. 158.)
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180. A course of instruction in meteorology. Letter of Oct. 14, 1893, to Seth Low, president of Columbia University. *See Science*, New York, Nov. 29, 1895, 2, 709-714, where its title reads "Meteorology in the University."
181. Relations of geodesy to meteorology; the deficit of gravity over the interior of the continents and its excess over the oceans. Read before the Philosophical Society of Washington, April 27,

1894. (Dated Feb. 22, 1894.) *See Amer. Met'l Jour.*, May, 1894, 11, 1-6.
182. International work in terrestrial magnetism. Letters of May 12 and 23, 1894. Published in *Trans. Astron. and Phys. Soc.*, Toronto, 1894, p. 33, p. 38. [On May 15th a committee was appointed with F. R. Stuart as chairman.]
183. Meteorological problems for mathematical students. Letter of February —, 1894, to Prof. James MacMahon, Cornell University. *In Amer. Met'l Jour.*, May, 1894, 11, 15-17.
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